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RETARDANT SALT CONCENTRATION MEASURED IN THE FIELD

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ABSTRACT

The effectiveness of long-term fire retardants is related to the concentration of the active fire-inhibiting salt. Quality control at each retardant base is necessary to assure that maximum effectiveness is obtained. This note describes simple field methods for determining the salt content of retardant solutions now in use.

Previous studies have indicated that the effectiveness of long-term fire retardants is related to the amount and type of active chemical salt present in a given fuel and fire situation. To assure that the desired salt concentration and effectiveness is obtained, retardant base personnel must have the capability of monitoring the salt content.

Previous methods of monitoring retardant quality have included viscosity and density measurements.[2] [3] Although viscosity is important because of its relation to aerial drop characteristics, it is not necessarily related to salt content. Viscosity has an important effect, however, on the amount of salt retained by aerial fuels. The viscosity of a retardant depends on the type and amount of thickening agent, water hardness, temperature, and method of mixing (shear, etc.). The density and specific

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[2]Charles W. George and Charles E. Hardy. Revised Marsh funnel table for measuring viscosity of fire retardants. USDA Forest Serv. Res. Note INT-91, 2 p., 1969.

[3]National Fire Protection Association. Chemicals for forest fire fighting. Ed. 2, p. 75-87. Boston: National Fire Protection Association, 1967.

gravity[4] are related to the concentration of salt and other ingredients in solution. The retardant salt is the primary ingredient in fire retardants and its concentration can be correlated to the specific gravity if the manufacturer's formulation remains constant. Past salt analyses show the manufacturer's formulation to remain acceptably constant if the samples are of an adequate size.

AVAILABLE MEASURING METHODS

Methods for measuring the density and specific gravity of retardants have included use of the Baroid mud balance[5] and the hydrometer. The mud balance consists of a graduated arm that has a constant volume cup attached to one end and an adjustable counterweight on the other end. The arm is scaled for both specific gravity and density. The hydrometer is a simple floating instrument which measures gravimetrically the buoyancy exerted on a glass-enclosed body of definite volume immersed in the liquid. The instrument is graduated in units of specific gravity.

Direct measurements of the specific gravity and density of retardants with the hydrometer and mud balance are complicated by the presence of thickening agents. These agents decrease the accuracy of such measurements for several reasons:

1. Viscous materials restrict free movement of the hydrometer and provide a poor meniscus. (The meniscus is the curved liquid surface in contact with the hydrometer.)

2. The volume of some types of thickening agents (especially clays) is dependent on the amount of hydration and mixing. Thus, a change in the volume and density may be due to changes in physical properties of the solution rather than a change in its salt content.

3. Air bubbles are common in freshly agitated retardant samples and cause errors in weight-volume measurements taken with the mud balance; also, bubbles affect the buoyancy exerted on a hydrometer.

FIELD PROCEDURES

The above problems can be solved by breaking down the thickening agent before measuring the specific gravity and estimating the salt content of presently used fire retardants. Retardants[6] presently being used and their major physical-chemical properties are given in table 1. The viscosity of highly viscous gum-thickened retardants such as Phos-Chek® 202 and 202XA can be reduced prior to determining the specific gravity by addition of a chemical known to break polymeric chains. A procedure to remove the clay from clay-thickened products, such as Fire-Trol 100, must be used because clay interferes with free hydrometer movement. Because of the nature of

[4]The density is the weight per unit volume. The specific gravity of a liquid is the ratio of its density to that of water at 4° C. and for practical purposes is equivalent to its density in grams per cubic centimeter.

[5]The Baroid mud balance is manufactured by the Baroid Division, National Lead Co., P.O. Box 1675, Houston, Tex. The use of firm names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product to the exclusion of others which may be suitable.

[6]The retardants presently being used and mentioned in this paper were formally submitted and evaluated under USDA Forest Service Interim Specification 5100-00301, Specification for Retardant, Forest Fire, Dry Chemical and Fixed-Wing Aircraft Application; or USDA Forest Service Interim Specification 5100-00302, Specification for Retardant, Forest Fire, Liquid Chemical, Unthickened for Aircraft or Ground Application.

Table 1.--*Physical-chemical characteristics of presently used fire retardants*

Retardant[1]	Recommended use level lbs./gal. of water or dilution rate[2]	Viscosity[3]	Density of slurry	Percent DAP $(NH_4)_2HPO_4$ or DAP equivalent	Percent ammonium sulfate $(NH_4)_2SO_4$	Percent[4] P_2O_5 equivalent	Specific gravity of slurry or filtrate (using analyses procedures)
		Centipoise	*Lbs./gal.*				
Phos-Chek 202	1.14	800-1500	8.9	10.6		5.7	1.072
Phos-Chek 202XA	1.14	1500-2000	8.9	10.6		5.7	1.072
Phos-Chek 259	1.60	50-100	9.1	15.0		8.1	1.095
Fire-Trol 930	4:1	5-60	9.1	16.2		8.7	1.096
Fire-Trol 931	4:1	30-120	9.2	15.4		8.3	1.092
Fire-Trol 934	4:1	5-60	9.1	15.8		8.5	1.094
Fire-Trol 100	2.78	1500-2500	9.4		15.6		1.101
Pyro (11-37-0)	5:1	50-100	9.0	14.9		8.0	1.078

[1]Phos-Chek is a product of Monsanto, St. Louis, Missouri. Fire-Trol is a product of Arizona Agrochemical Co., Phoenix, Arizona. Fire-Trol 930 is composed of Allied Chemical Co.'s Arcadian Poly-N 10-34-0 and a corrosion inhibitor. Fire-Trol 931 is composed of Allied Chemical Co.'s Arcadian Poly-N 10-34-0 and a corrosion inhibitor. Fire-Trol 934 is composed of Allied Chemical Co.'s Arcadian Poly-N 10-34-0, clay, coloring, and corrosion inhibitor. Pyro (11-37-0) is manufactured by Tennessee Valley Authority, Muscle Shoals, Alabama, and contains 1.5 percent $Na_2Cr_2O_7$ corrosion inhibitor.

[2]The dilution rate is by volume; a dilution rate of 4:1 means 4 gallons of water are added to 1 gallon of liquid concentrate to provide approximately 5 gallons of retardant solution.

[3]Viscosities by Brookfield viscometer Model LVF, at 60 r.p.m., spindle number 2 or 4.

[4]The P_2O_5 equivalent is determined from the percent by weight DAP using the formula: Percent P_2O_5 = percent DAP ÷ 1.86. The equivalent P_2O_5 content is not necessarily the same as the *active* salt content (because of other retardant ingredients) although the P_2O_5 equivalent can be used for quality control.

clay, it can be removed more readily by filtration than by use of flocculation agents. The specific gravity of products that have no thickening agent (Pyro, Fire-Trol 930 and 934) or gum-thickened products with only slight viscosity (Phos-Chek 259) can be determined without any special preparatory procedures.

Thus, because of the types of thickening agents, three different procedures are necessary for determining the salt content of present fire retardants. These procedures were developed by trial and error after excluding the possibility of devising a simple field method based on chemical analyses and are given in the three following sections.

1. Procedure for unthickened or thin, gum-thickened retardants--Pyro (TVA 11-37-0), Fire-Trol 930 and 934, and Phos-Chek 259.

2. Procedure for thick, gum-thickened retardants--Phos-Chek 202 and 202XA.

3. Procedure for clay-thickened retardants--Fire-Trol 100 and 931. Fire-Trol 931 is a clay-thickened, liquid concentrate which when diluted falls in the unthickened retardant category.

Following development of satisfactory field procedures, the specific gravity and the retardant salt content were correlated. For calibration purposes, a minimum of 10 samples of each retardant was prepared, varying only the mixing ratio or use level. This provided 10 different salt contents and specific gravities. The specific gravity was read while temperature of the solution was at 80±2° F. Using a computer method for linear regression, an equation was determined that fitted these points best in the least squares sense. The equation for salt content as a function of specific gravity was then evaluated and a table compiled. A correction factor was then calculated for retardant salt contents which deviated from the recommended salt content. *This use-level correction factor per 100 gallons of retardant solution will enable field personnel to adjust an improper salt content. (See the table for each product: tables 2, 3, 4, 5, 6, and 7).* Selection of a method for correction of an improper salt content will depend on the type of retardant, the mixing equipment, and the existing plumbing.

Under field conditions the specific gravity of a retardant solution or slurry may be measured at a temperature other than 80±2° F.; therefore, it was necessary to determine the effect of temperature on specific gravity. Samples of each retardant with the recommended salt content were prepared and the specific gravity measured at 10° intervals between 40° and 110° F. The effect of temperature on the specific gravity was found to be the same for all retardants, for all practical purposes. The average change in specific gravity was found to be approximately 0.002 specific gravity units per 10° F. Thus, if the specific gravity of the retardant solution cannot be measured near 80° F., the following rule of thumb should be applied: *For every 10° F. the retardant solution is below 80° F., subtract 0.002 from the hydrometer reading; or for every 10° F. the retardant solution is above 80° F., add 0.002 to the hydrometer reading.*

PROCEDURES FOR SPECIFIC PRODUCTS[7]

PROCEDURE FOR UNTHICKENED OR THIN, GUM-THICKENED RETARDANTS

Pyro (TVA 11-37-0), Fire-Trol 930 and 934, and Phos-Chek 259

The retardants are either unthickened, or thickened only slightly, and regular hydrometer readings can be taken.

1. Take a freshly agitated quart sample of the solution or slurry to be analyzed for salt content. (This sample will also be suitable for viscosity measurement, using the Brookfield viscometer or the Marsh funnel.) Allow the sample to reach room temperature (approximately 80° F.).

2. After all entrapped air bubbles are allowed to escape, measure the specific gravity of the solution using a high precision hydrometer (Sargent-Welch S-41885G for specific gravity 1.060 - 1.130 by 0.001 divisions). Be sure to let the hydrometer settle in the solution for 3 to 5 minutes before reading.

3. Record the specific gravity to the nearest 0.001 and extrapolate from tables 2, 3, and 4 the percent by weight, P_2O_5 equivalent, or DAP $[(NH_4)_2HPO_4]$ equivalent. (If the active chemical used in the retardant formulation was DAP, the percent DAP rather than P_2O_5 equivalent will appear in the first column following the specific gravity.)

[7]The equipment recommended for use in these field procedures is given on page 14 following the procedures.

Table 2.--*Pyro 11-37-0 salt content as related to specific gravity*[1]

Measured specific gravity of retardant solution	Percent P_2O_5 equivalent (by weight)	Percent DAP $(NH_4)_2HPO_4$ (by weight)	Correction[2] required per 100 gallons of retardant solution	
			Concentrate	Water
			Gals.	
1.045	4.9	9.1	8.1	
1.050	5.4	10.0	6.8	
1.055	5.8	10.8	5.8	
1.060	6.3	11.7	4.5	
1.065	6.8	12.6	3.2	
[3]				
1.070	7.3	13.6	1.9	
1.075	7.7	14.3	.8	
1.078	8.0	14.9	0	0
1.080	8.2	15.3		3
1.085	8.7	16.2		10
1.090	9.2	17.1		16
1.095	9.6	17.9		22
1.100	10.1	18.8		29
1.105	10.6	19.7		36
1.110	11.1	20.6		43
1.115	11.5	21.4		49
1.120	12.0	22.3		56
1.125	12.4	23.1		62
1.130	13.0	24.2		71
1.135	13.4	24.9		77
Expanded Scale				
1.150	14.9	27.7		99
1.175	17.2	32.0		135
1.200	19.6	36.5		174
1.225	22.0	40.9		214
1.250	24.3	45.2		255

[1]The recommended use level for Pyro 11-37-0 is 5 parts water to 1 part concentrate by volume. An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent P_2O_5 equivalent = 95.05 specific gravity - 94.44.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content.

Table 3.--*Fire-Trol 930 and 934 salt content as related to specific gravity*[1]

Measured specific gravity of filtrate	Percent P_2O_5 equivalent (by weight)	Percent DAP $(NH_4)_2HPO_4$ (by weight)	Correction[2] required per 100 gallons of retardant solution	
			Concentrate	Water
			Gals.	
1.060	5.6	10.4	10.2	
1.065	6.0	11.2	9.3	
1.070	6.5	12.1	6.5	
1.075	6.9	12.8	5.3	
1.080	7.3	13.6	4.1	
[3]				
1.085	7.7	14.3	2.8	
1.090	8.2	15.3	1.3	
1.095	8.6	16.0	0	0
1.100	9.0	16.7		5
1.105	9.5	17.7		12
1.110	9.9	18.4		17
1.115	10.3	19.2		23
1.200	10.8	20.1		29
1.125	11.2	20.8		34
1.130	11.6	21.6		39
1.135	12.0	22.3		45
1.140	12.5	23.3		52
1.145	12.9	24.0		57
1.150	13.3	24.7		63
1.155	13.8	25.7		70
	Expanded Scale			
1.175	15.5	28.8		94
1.200	17.6	32.7		126
1.225	19.8	36.8		160
1.250	21.9	40.7		193

[1]The recommended use level for Fire-Trol 930 and Fire-Trol 934 is 4 parts water to 1 part concentrate by volume. An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent P_2O_5 equivalent = 85.92 specific gravity - 82.09.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content.

Table 4.--*Phos-Chek 259 salt content as related to specific gravity*[1]

Measured specific gravity of retardant solution	Percent DAP $(NH_4)_2HPO_4$ (by weight)	Percent P_2O_5 equivalent (by weight)	Correction[2] required per 100 gallons of retardant solution	
			Retardant	Water
			Lbs.	*Gals.*
1.050	8.2	4.4	76	
1.055	9.0	4.8	68	
1.060	9.7	5.2	60	
1.065	10.5	5.6	51	
1.070	11.2	6.0	43	
1.075	12.0	6.4	34	
1.080	12.7	6.8	27	
1.085	13.5	7.3	17	
1.090[3]	14.2	7.7	9	
1.095	15.0	8.1	0	0
1.100	15.7	8.4		6
1.105	16.5	8.9		11
1.110	17.3	9.3		17
1.115	18.0	9.7		22
1.120	18.8	10.1		28
1.125	19.5	10.5		34
1.130	20.3	10.9		40
1.135	21.0	11.3		45
1.140	21.8	11.7		52
1.145	22.5	12.1		57
1.150	23.3	12.5		64

[1]The recommended use level for Phos-Chek 259 is 1.60 lbs./gal. of water. An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent DAP = 150.72 specific gravity - 150.05.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content.

PROCEDURE FOR THICK, GUM-THICKENED RETARDANTS

Phos-Chek 202 and 202XA[8]

1. Take a freshly agitated sample of the Phos-Chek® slurry to be analyzed for salt content (this sample will also be suitable for viscosity measurement, using either the Brookfield viscometer or the Marsh funnel). Allow the sample to reach room temperature (approximately 80° F.).

2. Using this sample, fill a quart jar one-half full. Then, using a teaspoon measure, *add two level teaspoon measures* (5 grams) of Phos-Chek® Breaker[9] to the sample. *NOTE: It is important that exactly the correct amount of Phos-Chek® Breaker be added.*

3. Shake vigorously for at least 30 seconds and loosen the lid to relieve air pressure and allow entrapped air bubbles to escape.

4. Allow the material to sit for 10 minutes.

5. Pour the material into a hydrometer cylinder and allow it to reach room temperature (approximately 80° F.). A 32 by 200 mm. test tube will suffice.

6. After allowing the material to sit for an additional 10 minutes (20 minutes from the time the enzyme was added), measure the specific gravity of the solution using a high precision hydrometer (Sargent-Welch S-41885G for specific gravity 1.060 - 1.130 by 0.001 divisions). Allow the hydrometer to settle in the solution for at least 1 minute before reading. *Do not allow any solution containing Phos-Chek® Breaker to be returned to the storage tank since a small amount can cause gradual reduction in viscosity of the entire tank.*

7. After recording the specific gravity to the nearest 0.001, extrapolate from table 5 the percent by weight DAP $[(NH_4)_2HPO_4]$ or P_2O_5 equivalent.

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[8]The procedure used for Phos-Chek 202 and 202XA is a modification of a method proposed by H. L. Vandersall and G. F. Snow, Monsanto Co., 1971.

[9]Phos-Chek® Breaker is a cellulase enzyme supplied by the Monsanto Co. Phos-Chek® Breaker packaged for fire retardant salt analysis can be obtained from the Northern Forest Fire Laboratory, Drawer G, Missoula, Montana 59801; or Monsanto Co., 810 East Main St., Ontario, California 91761.

Table 5.--*Phos-Chek 202 and 202XA salt content as related to specific gravity*[1]

Measured specific gravity of retardant solution	Percent DAP $(NH_4)_2HPO_4$ (by weight)	Percent P_2O_5 equivalent (by weight)	Correction[2] required per 100 gallons of retardant solution	
			Retardant	Water
			Lbs.	*Gals.*
1.030	4.0	2.2	72	
1.035	4.7	2.5	65	
1.040	5.5	3.0	56	
1.045	6.2	3.3	49	
1.050	7.0	3.8	40	
1.055	7.8	4.2	31	
1.060	8.5	4.6	24	
1.065[3]	9.3	5.0	15	
1.070	10.0	5.4	7	
1.074	10.6	5.7	0	0
1.075	10.8	5.8		2
1.080	11.5	6.2		9
1.085	12.3	6.6		17
1.090	13.0	7.0		24
1.095	13.8	7.4		33
1.100	14.6	7.8		41
1.105	15.4	8.3		50
1.110	16.1	8.7		57
1.115	16.9	9.1		66
1.120	17.6	9.5		73

[1]The recommended use level for Phos-Chek 202 and 202XA is 1.14 lbs./gal. of water. An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent DAP = 151.83 specific gravity - 152.42.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content.

PROCEDURE FOR CLAY-THICKENED RETARDANTS

Fire-Trol 100 and 931

1. Take a freshly agitated 1- to $1\frac{1}{2}$-quart sample of the Fire-Trol slurry to be analyzed for salt content. (This sample will also be suitable for viscosity measurement using the Brookfield viscometer or the Marsh funnel.)

2. Place the sample in an 8-inch funnel containing a rapid and fairly retentive filter paper (Sargent-Welch S-32915L general purpose filter paper). Collect 80 to 100 ml. of the filtrate. Fire-Trol 100 samples will require about 30 minutes depending partially on the viscosity. Fire-Trol 931 samples will require about 10 minutes.

3. Place the filtrate in a hydrometer cylinder and allow it to reach room temperature (approximately 80° F.). A 32 by 200 mm. test tube will suffice.

4. Measure the specific gravity of the solution using a high precision hydrometer (Sargent-Welch S-41885G for specific gravity 1.060 - 1.130 by 0.001 divisions). Allow the hydrometer to settle in the solution for 1/2 to 1 minute before reading.

5. Record the specific gravity to the nearest 0.001 and extrapolate from tables 6 and 7 the percent by weight ammonium sulfate $[(NH_4)_2SO_4]$, P_2O_5 equivalent, or DAP $[(NH_4)_2HPO_4]$ equivalent, depending on type of retardant.

Table 6.--*Fire-Trol 100 salt content as related to specific gravity*[1]

Measured specific gravity of filtrate	Percent $(NH_4)_2SO_4$ by weight	Correction[2] required per 100 gallons of retardant solution	
		Retardant	Water
		Lbs.	*Gals.*
1.045	7.3	154	
1.050	8.1	140	
1.055	8.8	127	
1.060	9.6	114	
1.065	10.3	100	
1.070	11.0	86	
1.075	11.8	73	
1.080	12.5	59	
1.085	13.3	45	
1.090	14.0	31	
1.095[3]	14.8	16	
1.100	15.5	2	
1.101	15.6	0	0
1.105	16.2		4
1.110	17.0		10
1.115	17.7		15
1.120	18.5		21
1.125	19.2		26
1.130	20.0		32
1.135	20.7		37
1.140	21.4		43
1.145	22.2		48
1.150	22.9		54
1.155	23.7		60
1.160	24.4		65

[1]The recommended use level for Fire-Trol 100 is 2.78 lbs./gal. of water. An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent AS = 148.40 specific gravity - 147.74.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content.

Table 7.--*Fire-Trol 931 salt content as related to specific gravity*[1]

Measured specific gravity of filtrate	Percent P_2O_5 equivalent (by weight)	Percent DAP $(NH_4)_2HPO_4$ (by weight)	Correction[2] required per 100 gallons of retardant solution	
			Concentrate	Water
			Gals.	
1.060	5.7	10.6	8.4	
1.065	6.1	11.4	7.1	
1.070	6.5	12.1	5.8	
1.075	6.9	12.9	4.4	
1.080	7.3	13.6	3.1	
[3]				
1.085	7.8	14.4	1.8	
1.090	8.2	15.2	.4	
1.092	8.3	15.4	0	0
1.095	8.6	16.0		4
1.100	9.0	16.7		9
1.105	9.4	17.5		15
1.110	9.8	18.3		20
1.115	10.2	19.1		26
1.120	10.6	19.8		32
1.125	11.1	20.6		38
1.130	11.5	21.4		43
1.135	11.9	22.1		49
1.140	12.3	22.9		55
1.145	12.7	23.7		61
1.150	13.1	24.4		67
	Expanded Scale			
1.175	15.2	28.3		98
1.200	17.3	32.1		130
1.225	19.4	36.0		163
1.250	21.4	39.8		198

[1]The recommended use level for Fire-Trol 931 is 4 parts water to 1 part concentrate (by volume). An adequate specific gravity and salt content corresponding to this use level is outlined within the table. Values for salt content were determined from the equation: Percent P_2O_5 equivalent = 82.80 specific gravity - 82.09.

[2]Correction needed to obtain the recommended salt content.

[3]The lined area indicates a satisfactory salt content exists and no adjustment is needed. The satisfactory salt content was determined by allowing approximately a 10-percent deviation above and below the recommended salt content

EQUIPMENT

THE FOLLOWING EQUIPMENT RECOMMENDED FOR USE IN FIELD PROCEDURES[10]

1. *Procedure for unthickened or thin, gum-thickened retardants*

   Pyro (TVA 11-37-0), Fire-Trol 930 and 934, and Phos-Chek 259

   A. Quart jar or plastic bottle (S-8416, 32-ounce; 50 cents each).

   B. Hydrometer[11] (S-41885G 1.060 to 1.130 by 0.001 divisions; $3.75 each).

2. *Procedure for viscous, gum-thickened retardants*

   Phos-Chek 202 and 202XA

   A. Quart jar or plastic bottle (S-8416, 32-ounce; 50 cents each).

   B. Measuring teaspoon (obtained from hardware store).

   C. Hydrometer[11] (S-41885G 1.060 to 1.130 by 0.001 divisions; $3.75 each).

   D. Phos-Chek® Breaker, a cellulase compound, can be obtained at no cost from the Northern Forest Fire Laboratory, Drawer G, Missoula, Montana 59801; or the Monsanto Company, 810 East Main Street, Ontario, California 91761.

3. *Procedure for clay-thickened products*

   Fire-Trol 100 and 931

   A. Funnel (S-35433F, 8-inch diameter, short stem; $2.75 each).

   B. Filter paper (S-32915L No. 500, 40-cm. diameter; $3.62 per package of 100).

   C. Test tube (S-79540W 32 by 200 mm.; 48 cents each).

   D. Hydrometer[11] (S-41855G 1.060 to 1.130 by 0.001 divisions; $3.75 each).

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[10]The equipment used to prepare the tables was obtained from Sargent-Welch, 4040 Dahlia, Denver, Colorado 80207, telephone 303-399-8220. The numbers refer to Sargent Catalog 115 numbers. Field use of similar equipment would help insure reliable results.

[11]For specific gravity measurements outside the normal range 1.060 to 1.130, an appropriate hydrometer may be obtained ($3.75 each):

S-41885F 1.000 to 1.070 by 0.001 divisions
S-41885H 1.120 to 1.190 by 0.001 divisions
S-41885I 1.180 to 1.250 by 0.001 divisions